

Components of Fingerprint Image Quality

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Agenda: Components of Quality



Sr. Francis Galton

- I. Image Formation
- II. Finger Contact Components
- III. Technical Components
 - Spatial Resolution
 - Sampling
 - Grayscale
- IV. Summary

Fingerprint Image Formation

■ Ink

- Finger contacts ink
- Finger contacts paper
- Ink transferred to paper (*printed*)
- Printed ink transfer scanned



■ Livescan

- Finger contacts image surface (*imprinted*)
- Contact surface with *imprinted* ridge pattern scanned

■ Contact is an essential element of friction ridge image formation

- Basis of the Science of Fingerprints



Livescan Imprint Image Formation

■ Optical

- Frustrated Total Internal Reflection (FTIR)
- Intimate Contact Required

■ Poor Contact

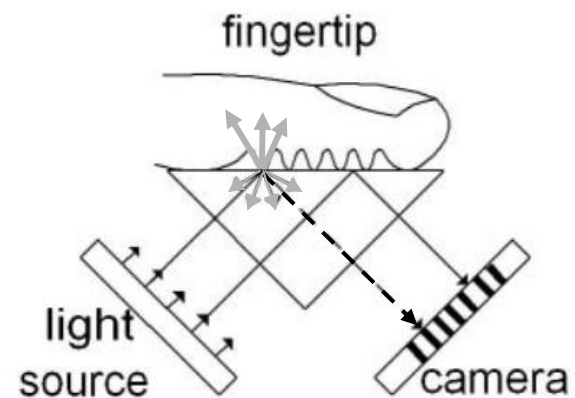
- Light (Weak) Ridge
- Low Contrast

■ Membrane or Damp Skin

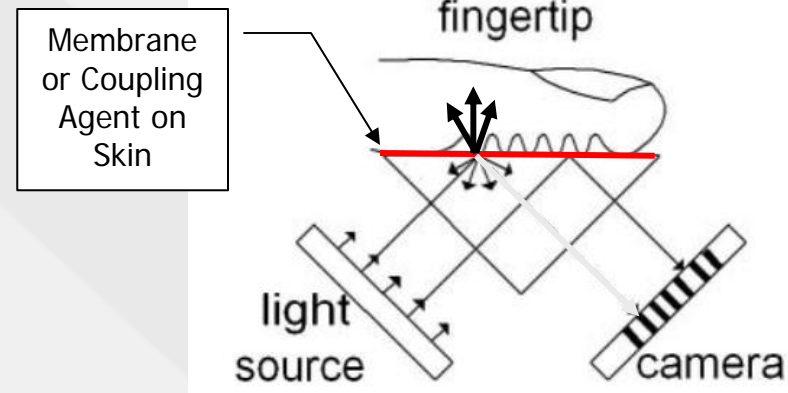
- Enhances Contact
- Dark (Strong) Image

■ Morphology

- Dry skin
- Wet skin
- Damaged skin



Light (weak) Ridge



Dark (strong) Ridge

Component 1: Contact

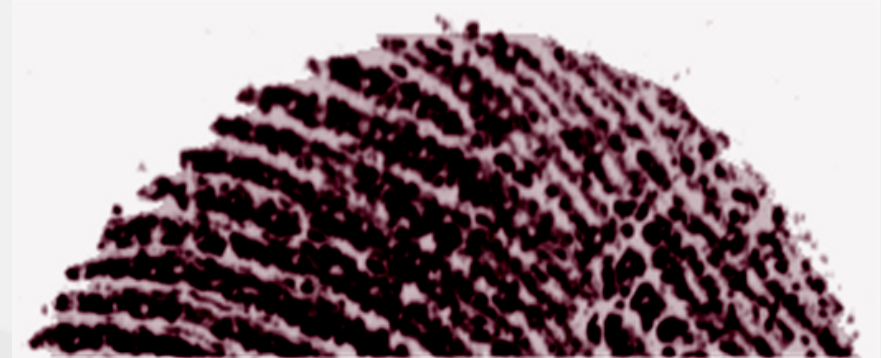
- Dark ridges -- Soft Membrane or Very Moist Skin (without Moisture Discriminating Optics*)
- Light images – Dry Skin
- Motion Effects -- Finger Motion Un-controlled
- Image not fully formed -- Abbreviated Roll

***Moisture Discriminating Optics
Will Not Image Excess Moisture**

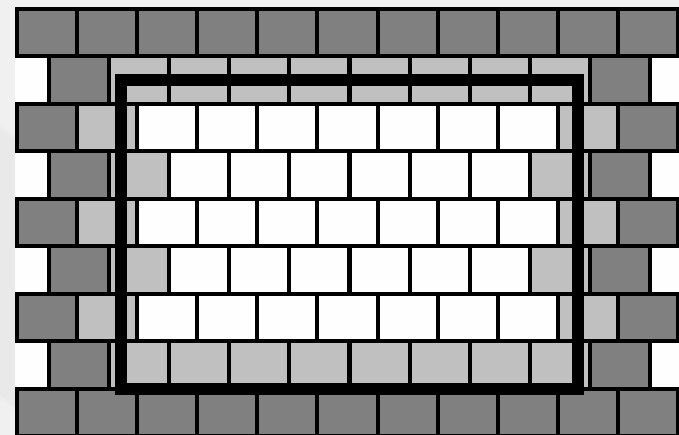


Quality Control Measures

- Accurately Detect Finger Contact
- Establish Measurement Structure Within Detected Contact
- Analyze the Structure
 - Light cells
 - Dark cells
 - Smeared Cells
 - Total cells
- Provide User Feedback to Improve Quality
 - Calculate % bad cells, compare to a threshold



Detected Contact Illustrated
In Color



Measurement Structure Illustration

High Quality Image



REVIEW

Right Thumb



PASS

Score: 94
Required: 75

Save to Save Image

Scan to Re-Capture

Abort

Quality Control Measure Examples

- Image Not Formed Correctly

- Algorithm dynamically determines roll width
- Rejects image if too narrow



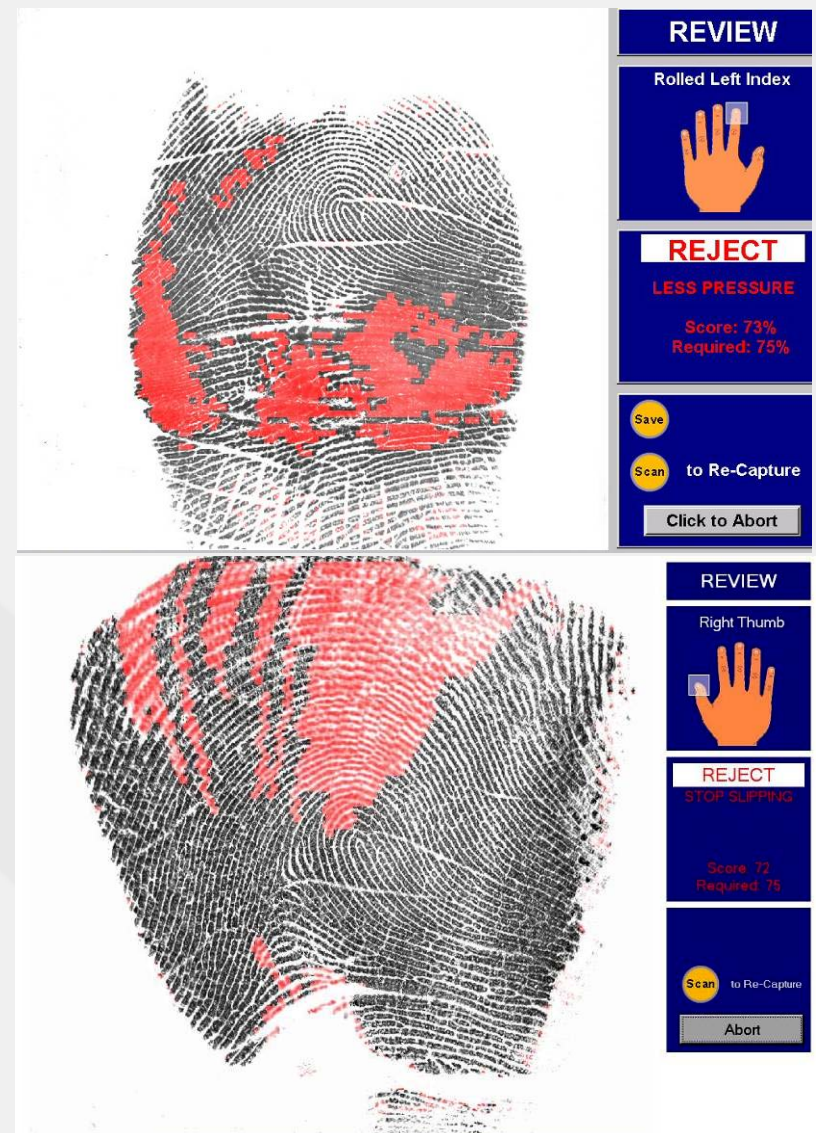
- Dry Finger -- Image Too Light

- Too light cells marked for operator visual cue
- Rejects image if too many light cells



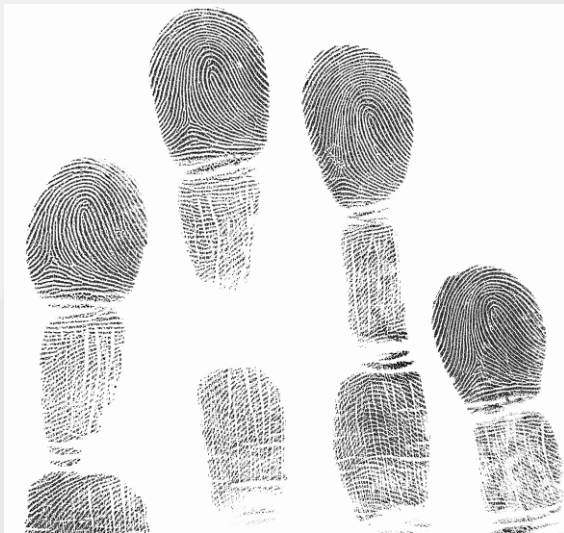
Quality Control Measure Examples

- Heavy Pressure Around Knuckle -- Image Too Dark
 - Too dark cells marked for operator visual cue
 - Rejects image if too many dark cells
- Image Intentionally Smeared
 - Smeared cells marked for operator visual cue
 - Rejects image if too many smeared cells



AutoCapture --ID Slap Device

- Combine QA Measures to Accomplish AutoCapture
- If Contact is Satisfactory
 - Area of Coverage
 - Contrast
- Indicate Quality Per-Finger by red/yellow/green feedback
- When All Green
- Grab Image

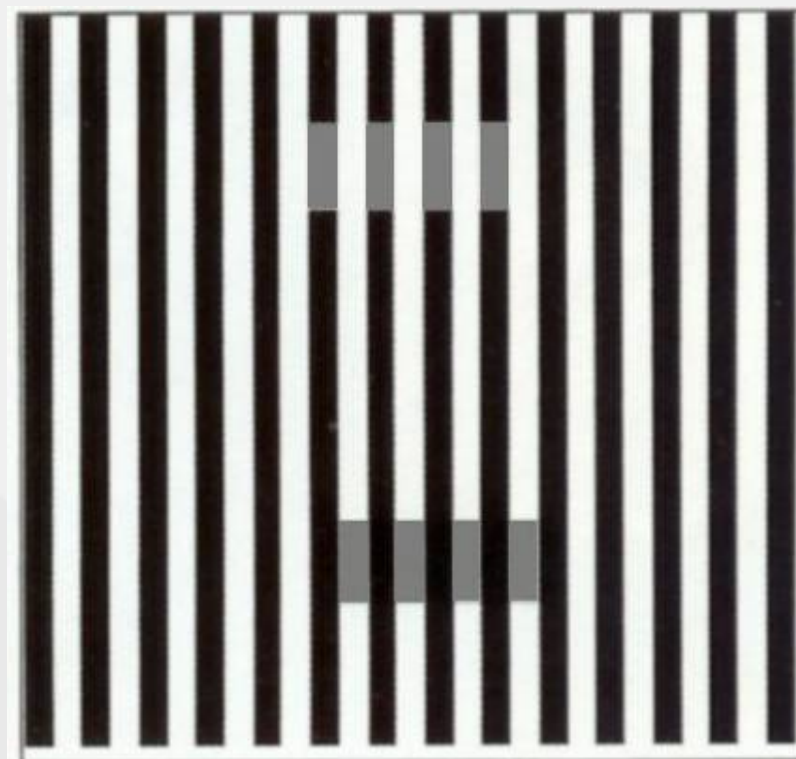
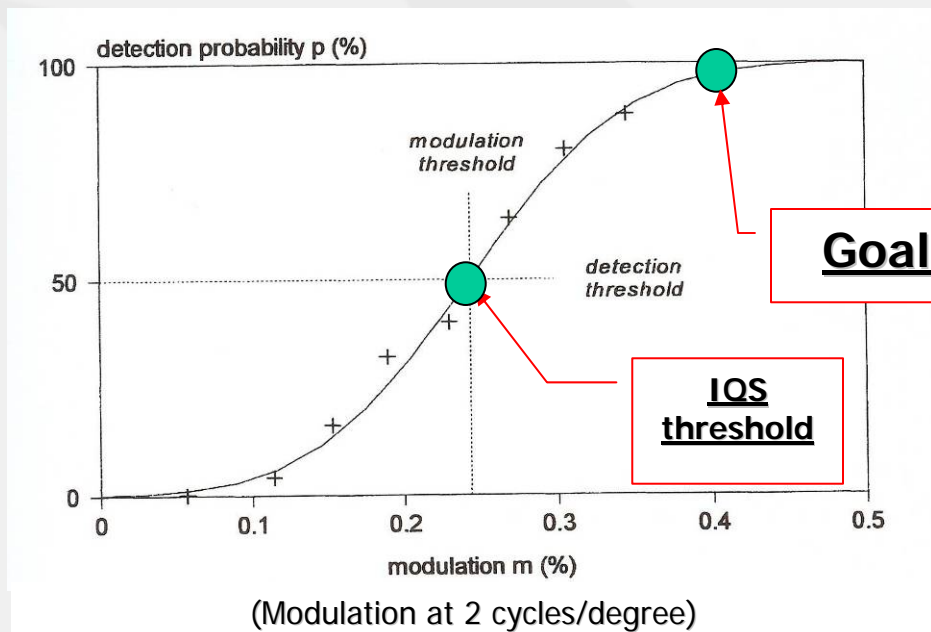


Psychometric Function (Galton's ogive)

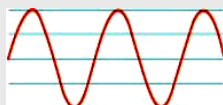
The Eye (Detection Device) is Sensitive to Modulation

■ Detection Threshold = 50%

■ Modulation Threshold = 0.25



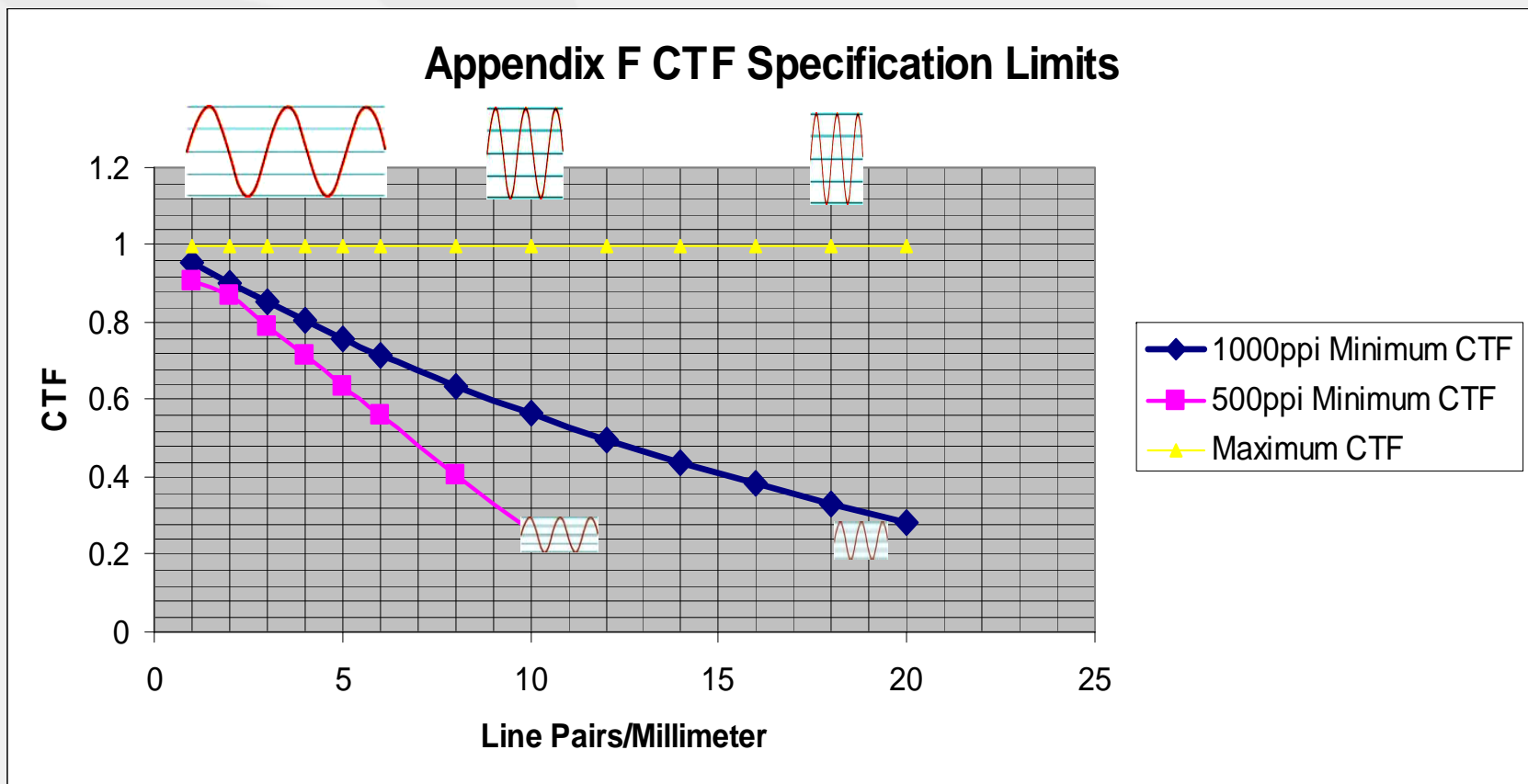
Illustrates Different Modulation Levels



Component 2: Spatial Resolution

IQS Minimum Modulation Limits

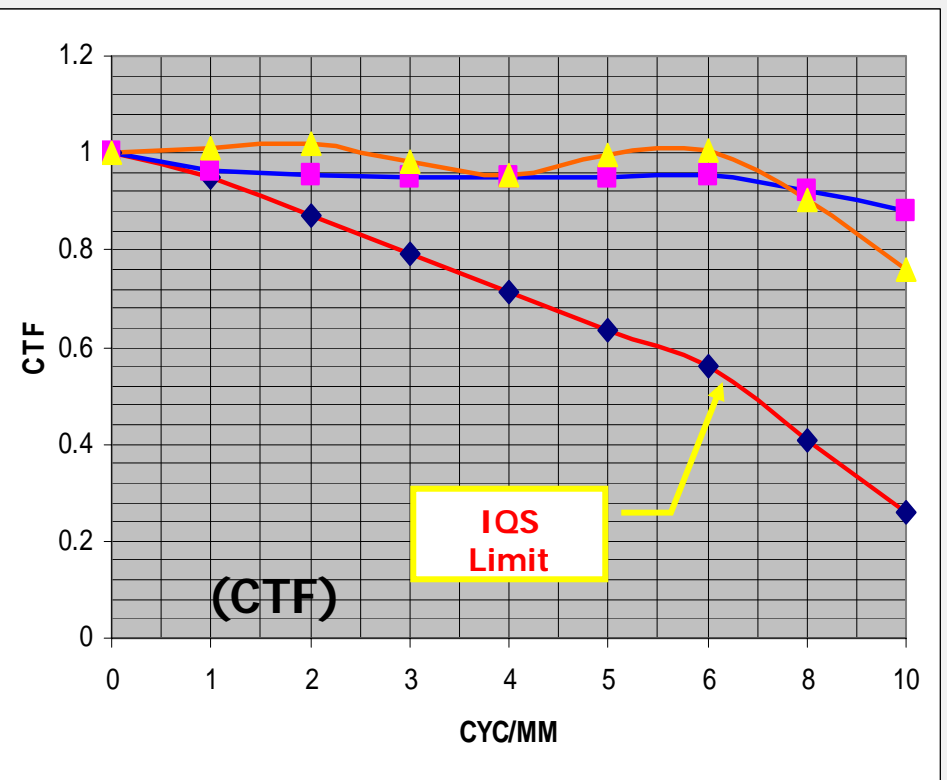
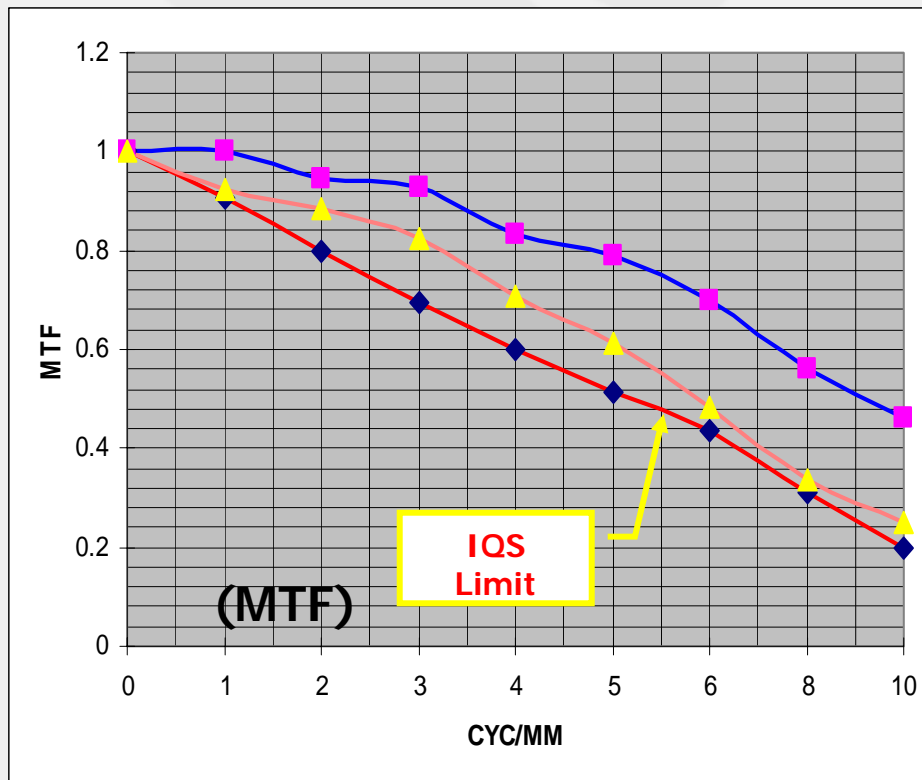
- High CTF (MTF) means higher contrast
- High contrast means higher quality



Resolution: Optics MTF x Imager MTF

- 500 ppi optics & imager
- 500 ppi output

- 1000 ppi optics & *high pixel-density imager*
- 500 ppi output



High Pixel Density Image Capture



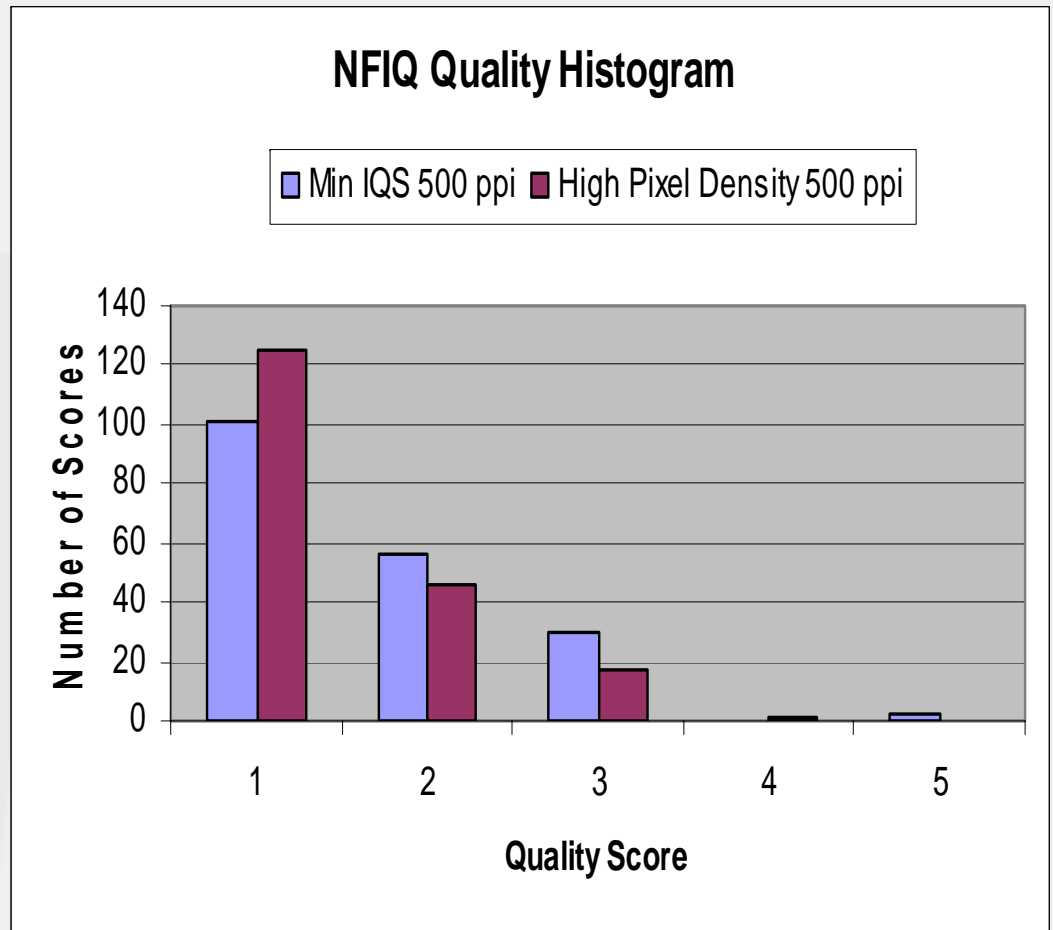
500 ppi optics,
sampling, and
output format

- 1000 ppi Optics wherever possible
- Over-sample in Both Horizontal and Vertical Domain -- Maximize MTF/CTF
- Scale to Final Image Format
- Superior Image Clarity

1000 ppi optics,
High Pixel Density
Sampling, and 500
ppi format

Measured Results with NFIQ

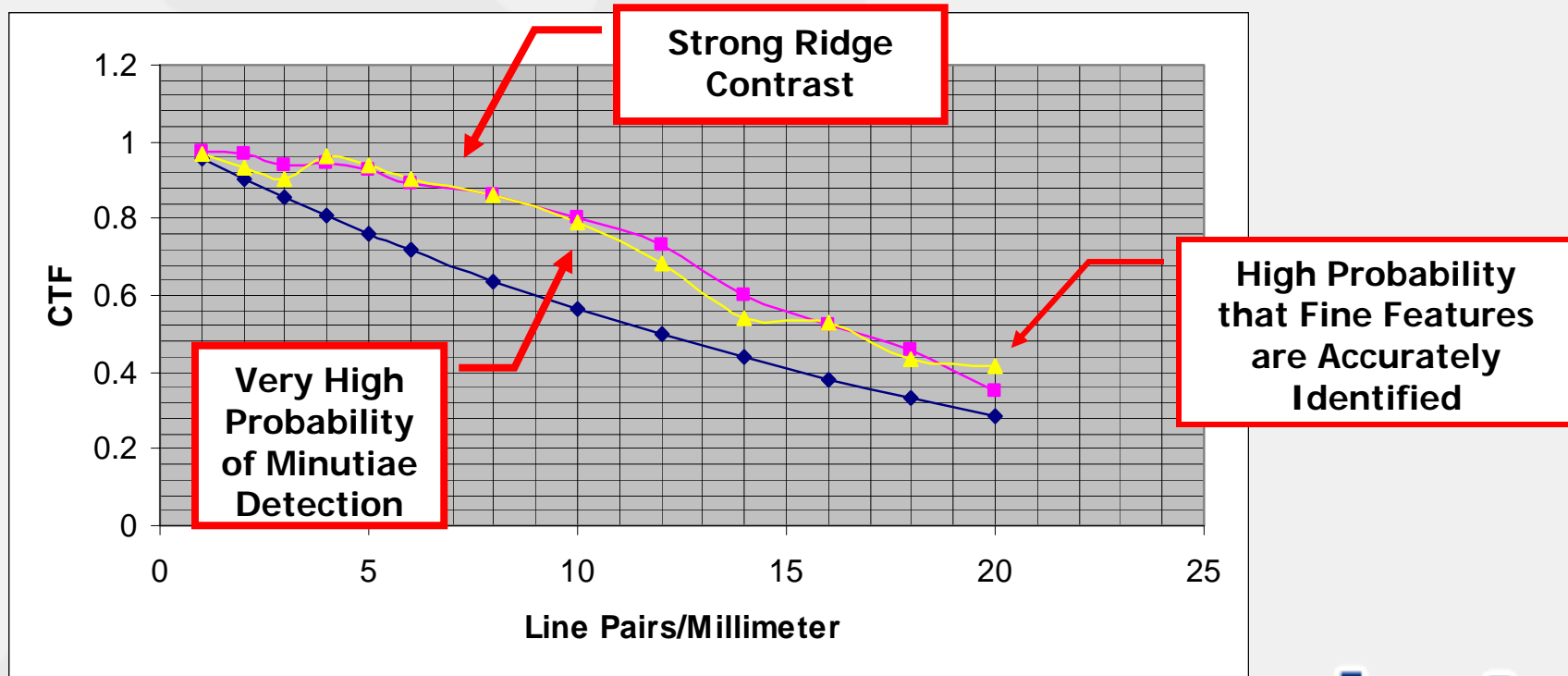
- 19 subjects
- Standard 500 ppi vs High Density 500 ppi
- ***Statistically significant shift from level 2 and 3 to level 1.***
- *".. The impact of image quality is greater than the impact of the difference in algorithms"*
 - NISTIR 7110, May 2004, p.26



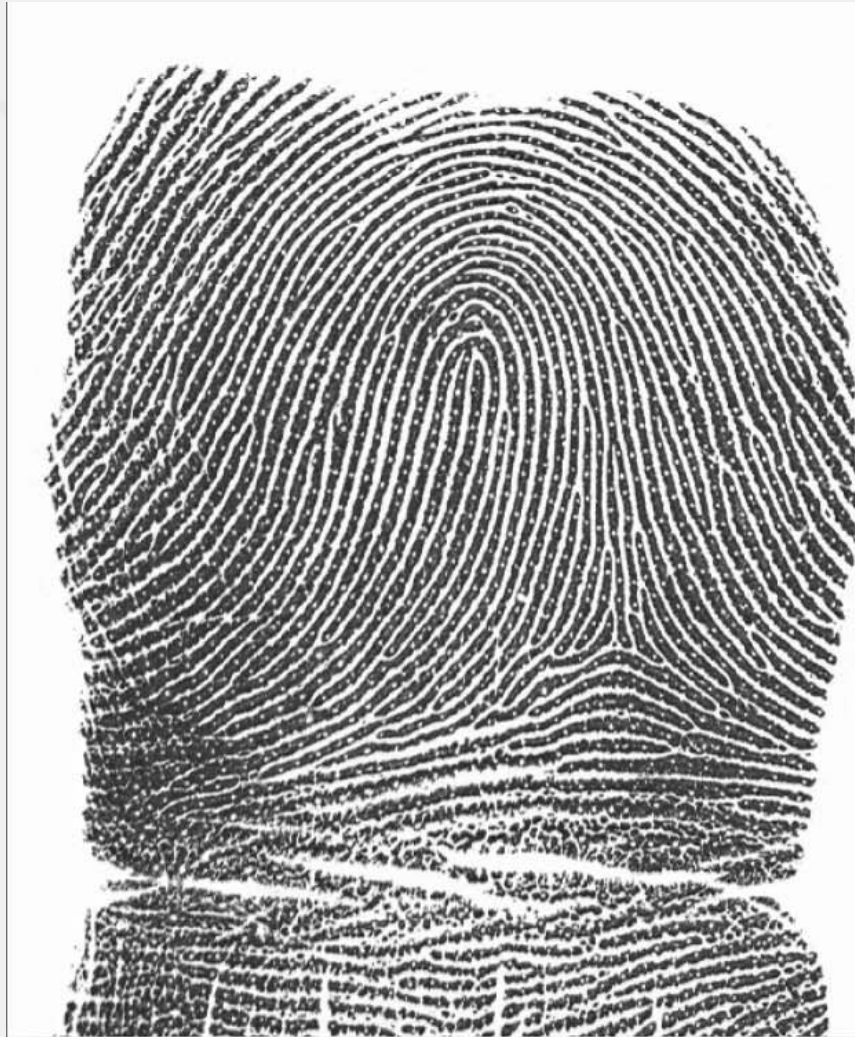
Component 3:

1000 ppi Image Format

- High sampling ensures good contrast and no aliasing for small correlated features as small as .002 inches
- Less pixelization at high magnifications
- High pixel density provides strong 10 cyc/mm response



500 High Pixel Density ppi vs. 1000 ppi



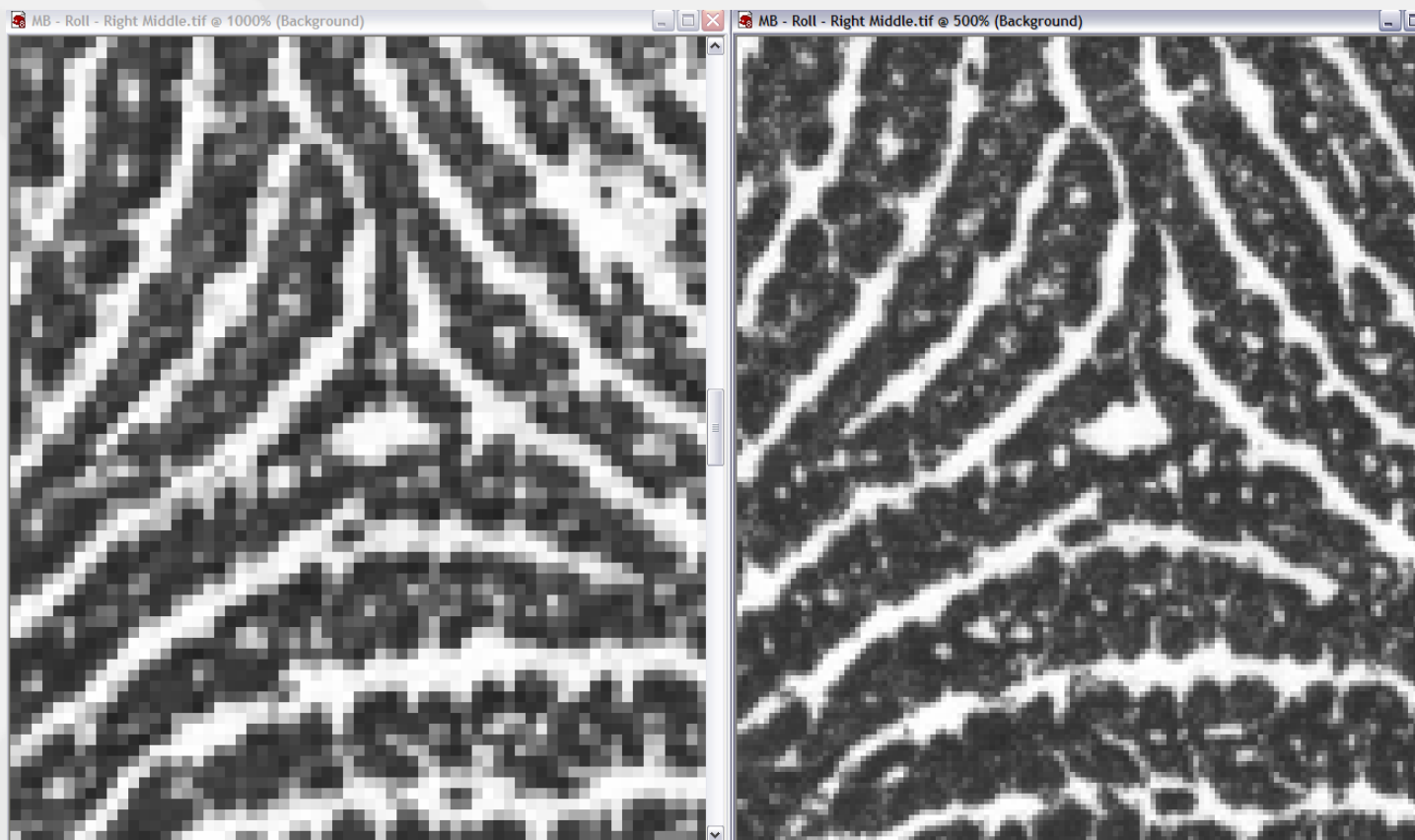
High Pixel Density 500 ppi



1000 ppi

1000 ppi

- High Contrast and Small Pixel Size



High Pixel Density 500 ppi

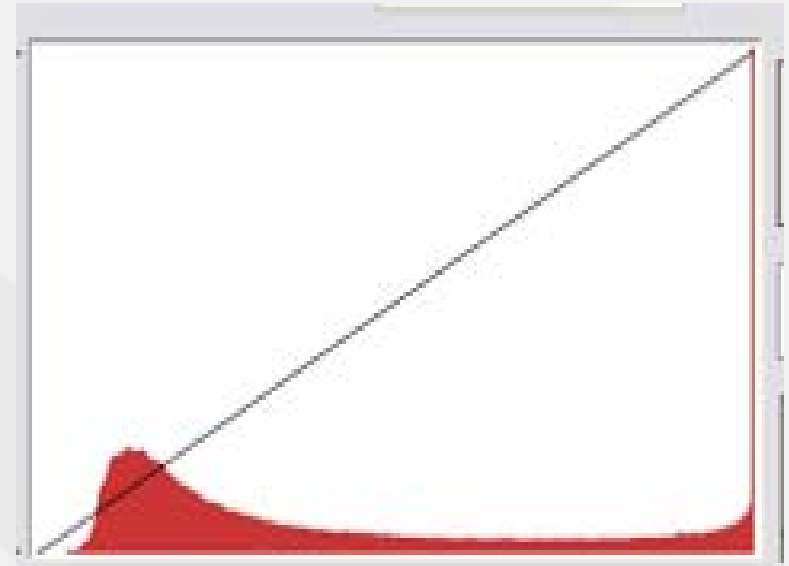
1000 ppi

Component 4: Grayscale



1000 PPI Image

- Large number of gray levels
- Linear
- No clipping below white

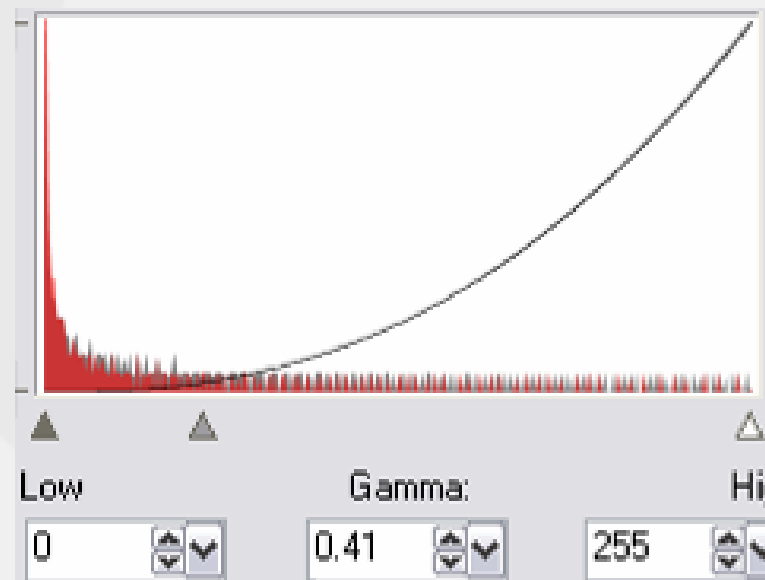


Non-Linear Grayscale

- Black clipping and gamma < 1.0
- Imager compression; contrast enhancement



Linear Grayscale



Non-Linear Grayscale 1000 ppi



Moderate Non-Linearity

Severe Non-Linearity

■ Inter and Intra Ridge Detail Lost

Summary

- Image Quality Analysis During Image Capture
- Operator QA Feedback to Apply Corrective Measures Prior to Saving
- Provide Means to Auto-Capture Where Appropriate
 - ID Slaps
- 1000 ppi Imaging Techniques for Higher CTF, Higher Contrast for All Ridge Events
 - 1000 PPI Optics
 - >500 ppi Sampling
- Maintain Grayscale Linearity
 - Avoid Masking Image Detail



Thank You!